

Choosing Cost-Effective Maintenance

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ABSTRACT

This report describes a project conducted under the guidance of the Pavement Maintenance Strategies Task Force with two objectives:

- (1) to develop corrective pavement maintenance guidelines for use by maintenance patrol staff which suggests a method for evaluating pavement distresses and the appropriate, cost-effective and practical maintenance treatment alternative; and
- (2) to conduct a pilot implementation of the developed guide specifically to verify the procedures for full implementation at a later stage.

The method used to develop the guide, was to utilize existing state-of-the-art in the area of pavement maintenance quality standards and related management systems/data, combined with the judgement of experienced individuals in the pavement design and evaluation, construction, and maintenance fields. The major emphasis was on the collection of subjective performance data on various maintenance treatments through personal interviews with experienced maintenance personnel. This material was incorporated into a "Working Copy" of the pavement maintenance guide.

The pilot implementation was based on the "Working Copy" and a combination of an audio/visual presentation and individual instruction of selected maintenance patrol staff. This was followed by a return visit to patrols and interviews for obtaining comments on the utility, ease of use, and validity of action levels described in the guide. Pilot implementation was conducted in 14 patrols in the 5 regions of the province.

The results obtained confirmed that the "Working Copy" of the pavement maintenance guide could, with some minor changes and improvement, be adopted for full implementation in the province.

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1/ INTRODUCTION

As the commercial on screen unfolds, the richly-dressed elderly lady with the chauffeur, and the Mercedes-Benz hoisted on high in the background, stresses the point that her enviable life-style was achieved through shrewd investment in material goods that are of lasting value. Furthermore, she maintains her affluent life-style by protecting her investments against undue depreciation through a program of cost-effective maintenance. She has chosen Speedy Muffler King to do the corrective maintenance necessary on her car's muffler because of their life-time guarantee. Her message is simple: protect your investment by timely maintenance at the cheapest cost or suffer the consequence of reduced resources, as in the case of her "Major" who unfortunately did not last forever, perhaps because of lack of maintenance, cost-effective or otherwise. This message, a perfectly sound management practice at any time, is particularly fitting in this time of high inflation and fiscal restraint.

The extensive highway system in Ontario, like the lady's fine car and jewelry, has been a very sound investment because benefits accrued to the public have been many times the money spent. The system represents many billions of dollars of public funds and is a valuable asset which must be protected against unwarranted deterioration that can affect the useful service life as well as the quality of service offered the public. In addition, emphasis is now not only to protect, but to prolong the pavement service life, because continuing budgetary constraints will surely result in the curtailment and postponement of capital expenditures for the highway system.

In order to achieve the twin objectives of protecting and prolonging the service life of the pavements in the system, a maintenance program which promotes timely maintenance and fosters cost-effectiveness, is needed. In Ontario, a systematic

approach to the total maintenance picture has recently been developed that tries to incorporate these needs. The two principal features of the approach are these:

- (1) Pavement quality standards for the maintenance management system are being revised to introduce more uniform methods of deficiency identification, and to foster corrective actions which are estimated to be most cost-effective. This is termed "Corrective Maintenance".
- (2) Complementing these deficiency-corrective actions are the courses of action which anticipate the occurrence of deficiencies or which are intended to retard progression of defects. This is termed "Preventive Maintenance".

The corrective maintenance measures are carried out to protect the integrity and safety requirements of the pavement system and the development and implementation of this corrective maintenance management process is the subject of this report. The preventive maintenance feature of the systematic approach deals with those actions staving off the inevitable consequences of age and traffic. Development in this area is described elsewhere (1).

2/ OBJECTIVES

The basic objectives of this study were:

- (1) The development of a corrective maintenance guide to be used in identifying the most suitable type of maintenance treatment for any given pavement condition, and the most appropriate timing of the application.
- (2) The development of a process for evaluating the cost-effectiveness of various maintenance treatments.
- (3) Pilot implementation to confirm the systematic management process of corrective maintenance represented by this guide as the proper and effective methodology for full implementation.

3/ APPROACH

The chief aim of the guide is to help patrolmen, patrol supervisors, and district maintenance staff to identify the most cost-effective maintenance treatment method for any given pavement distress problem. Therefore, this guide must include four basic elements:

- (1) It must offer a simple and functional system of identifying and describing the distress problem.
- (2) It must offer a list of appropriate alternative solutions to correct the problem.
- (3) It must offer a standardized methodology for cost-effectiveness comparison to generate the most desirable solution.
- (4) It must offer a standard for quantity and quality of work output for each possible solution.

There previously existed approved Ministry methods to identify and describe various pavement distresses, used in assessing pavement condition ratings (2, 3). The same holds true for maintenance quality and performance standards (4). These methods and standards served as the basis for formulating this guide.

The general approach used for the project can be described as follows:

- (1) Use the existing methods and standards to formulate a functional but comprehensive format which contains the four basic elements outlined above. Obtain estimates of 'life' of treatments by means of interviews of experienced maintenance staff.
- (2) Verify this format as to its functional practicability through personal interview of experienced personnel.
- (3) Formulate a "working" guide for pilot implementation and verification.
- (4) Assess the pilot project results to establish the final product, "Pavement Maintenance Guidelines -- Distresses, Maintenance Alternatives and Performance Standards".

4/ FORMULATING THE GUIDE

The aim is to provide a practical guide for our District maintenance field staff to use in their day-to-day operations. Use of this guide does not require our field staff to produce an inventory of pavement distresses. It is not a full-bloom pavement management system, but it is an important part of our overall pavement maintenance strategies.

While it is not practical to reproduce the guide here, showing a typical example will enable the reader to comprehend the structure of the guide. The example chosen is the treatment of alligator cracking.

4.1/ Pavement Condition Survey Scheme

The first requirement of the guide is a system of identification and description of various pavement distresses. This system must be simple and direct because it is not the function of the district maintenance field staff to trace the performance history of the highway pavements or to evaluate the pavement performance periodically to satisfy a data bank. For field staff, it is only important that it provide detailed descriptions of the extent of occurrence (density) and severity of any specific distress so that an appropriate maintenance treatment can be chosen.

Therefore, the simple scheme is based on word descriptions and action-oriented classification scales because:

- (a) word descriptions are on a value scale in common everyday use;
- (b) the surveyor assesses and describes conditions in familiar terms;
- (c) the surveyor is only concerned about what action to take in view of the extent of occurrence (density) and severity of the distress; and
- (d) the word descriptions directly help in identifying appropriate alternative maintenance treatments.

4.1.1/ Example of Distresses - Alligator Cracking

Table 1 shows how the terms "local" and "general" are used to describe the extent of occurrence (density) of any pavement distress. Eight types of distress for flexible pavements and ten types of distress for rigid pavements are included in the guide. The extract from the guide shown in Figure 1 illustrates a typical format used to describe a pavement distress, in this case alligator cracking.

Table 1/ Classification of Distress Density

CLASS	GUIDELINES
	(Based on percent of surface area in the pavement section affected by distress)
LOCAL:	Less than 30% of pavement surface area is affected by distress; Distress is spotted over localized areas only.
GENERAL:	More than 30% of pavement area is affected by distress; Distress is spotted evenly over the entire length of the pavement section.

4.2/ Maintenance Treatment Alternatives

Maintenance treatment alternatives run from simple spray patching to full-width machine-laid hot mix patching, and even to full-width single-course hot mix resurfacing. However, in spite of the many maintenance treatments available, there is a more limited selection suitable for correcting any particular distress condition. This is because the appropriateness of the treatment depends on the distress, the stage to which it has progressed, the timing of the treatment, the class of road and type of traffic, the traffic volume, the availability of materials, equipment and funds, etc. Nevertheless, it is useful to have a uniform approach to the evaluation and description of pavement distresses which is co-ordinated with corresponding sets of suitable maintenance alternatives from which effective solutions may be chosen.

4.2.1/ Example of Maintenance Treatment Alternatives

Table 2 illustrates how appropriate maintenance treatments are identified based on the evaluation of severity and density of the distress (Column 1 of Table 2). If, for example, moderate

Figure 1/ Alligator Cracking - An Extract from the Pavement Maintenance Guide

Description:	Cracks form a network of multi-sided (polygon) blocks resembling the skin of an alligator. The block size can range from 5 to 10 cm to about 50 cm. The alligator area may or may not be accompanied by distortion in the form of depression, and may occur anywhere on the pavement surface.	
Possible causes:	1. Insufficient pavement strength. 2. Poor base drainage and stiff or brittle asphalt mix at cold temperature.	
Severity:	Class.	Guidelines (Base on appearance and surface distortion)
	<i>Slight</i>	Alligator pattern established with corners of polygon blocks fracturing
	<i>Moderate</i>	Alligator pattern established with spalling of polygon blocks
	<i>Severe</i>	Polygon blocks begin to lift; may or may not involve potholes.
Density:	<i>Local:</i>	Less than 30% of pavement surface affected; distress spotted over localized areas only.
	<i>General:</i>	More than 30% of pavement surface affected; distress spotted evenly over entire length of pavement section.

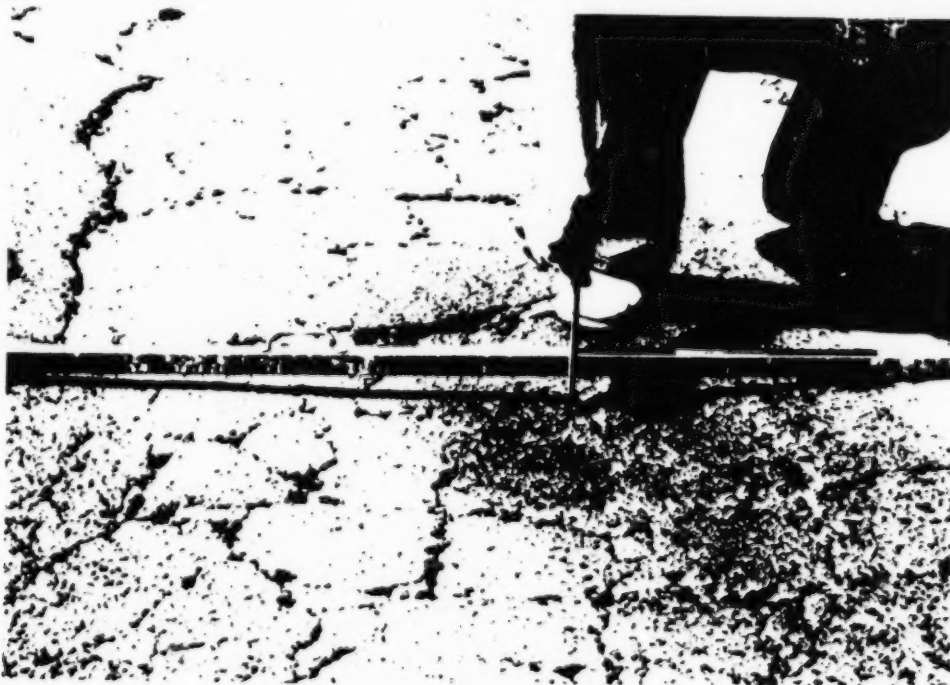


Table 2/ Example of Maintenance Treatment Alternatives

Treatments for Alligator Cracking

Evaluation		Recommended Maintenance Treatment Alternatives	Maintenance Function Classification		Expected Effective Life in Years
Severity	Density		Routine patrol	Non-patrol	
Slight	Local	No Action			
	General	No Action but monitor closely for future development			
Moderate	Local	Spray Patch	1004		1
		Cold Mix Patch	1001		1
		Hot Mix Patch	1001 1002	1002	4
		Hot Mix Patch for multi-lanes		1002	4
	General	Same as above but notify District Office of situation and maintain close monitoring			
Severe	Local	Cold Mix Patch	1001		0.5
		Hot Mix Patch	1001 1002	1002	3
		Excavate, Granular and Hot Mix Patch	1002	1002	7
		Improve Drainage (additional)	*	*	
	General	Hot Mix Patch for highways with AADT < 2000 and notify District Office	1002		2
		Mulching for AADT < 2000		1014	3
		Granular Lift and Surface Treatment for highways with AADT < 2000		1017	4
		Hot Mix Patch over selected areas and notify District Office for further action for highways with AADT > 2000	1002	1002	3

* Contract only.

local alligator cracking is the condition, the alternatives suggested are spray patching, cold mix patching, hot mix patching, or hot mix patching for multi-lanes (Column 2 of Table 2).

4.3/ Maintenance Treatment Performance Standard

Maintenance treatment alternatives can vary from work which can be done by patrol and equipment crews, to work which needs specialized equipment and skilled personnel, and to full-scale contract work. In general, routine corrective and small-scale preventive maintenance works are usually handled by patrol-size crews. Capability is generally dependent on size of job and equipment and manpower availability.

For these routine corrective and small-scale preventive maintenance activities, Performance Standards are available to help the district maintenance staff plan, budget and schedule their work by giving them necessary information to estimate costs, to estimate production quantities and material needs, to schedule men and equipment for the job, and to provide the procedural steps making up the maintenance method to ensure work quality.

4.3.1/ Example of Performance Standards

Against each of the alternative maintenance treatments listed in 4.2.1, under the general heading of "Maintenance Function Classification", Column 3 in Table 2, there are "Maintenance Performance Standards" numbers listed either as "routine patrol" or "non-patrol". Where the number is listed under the "routine patrol", it conveys the message that the work is within the capability of average maintenance patrol forces. Listing under "non-patrol" conveys the message that additional resources are needed and must be provided, either by combining patrol forces or by contracting out the work.

4.4/ Cost-Effectiveness

The mission of the maintenance staff is to select the most cost-effective maintenance treatment appropriate to the particular situation, to ascertain its practicability and to carry out the maintenance.

Cost comparison of maintenance alternatives is best made with their Equivalent Annual Costs which are based on the cost of doing the job and the expected life of the work accomplished. The Performance Standards provide the estimated cost of each maintenance alternative chosen which is the basic Unit Cost. That is:

$$\frac{\text{Manpower} + \text{Equipment} + \text{Materials}}{\text{Accomplishment per Day}} = \text{Unit Cost}$$

To obtain the Equivalent Annual Cost, which is the indicator used to evaluate cost-effectiveness, the Unit Cost is matched against the Life Expectancy of the Maintenance Treatment. That is:

$$\frac{\text{Unit Cost}}{\text{Expected Life of Alternative in Years}} = \text{Equivalent Annual Cost}$$

"Expected Life" is defined as the time in years (or months, or even weeks) before the distress treated reappears and progresses to the condition which existed prior to the treatment. The "Expected Life" given for each maintenance alternative under a particular situation represents the median value of estimates obtained through interviews with experienced maintenance staff, (Sec. 5.1).

4.4.1/ Example of Cost-Effectiveness

Column 4 in Table 2, "Expected Effective Life in Years", gives four years as the life for Hot Mix Patching, 1001 and 1002, for correction of moderate local alligator cracking, and one year as the life for either Cold Mix Patching or Spray Patching. The details of comparison of cost-effectiveness for these alternatives in this situation are given below.

In determining the most cost-effective maintenance treatment available, the cost of every recommended alternative must be compared: the cost of manpower, equipment and materials are the major components which determine the cost of each alternative. The following must be calculated.

1/ The Required Crew Size, Equipment and Materials - Performance Standard, M-1002: The required crew, equipment and materials are stated in the maintenance performance standards (Table 3). In this table, machine patching performance standards suggest a crew size of 6 - 12 men.

Equipment: 1 crew carrier
 1 grader or tailgate spreader
 1 roller
Materials: cold mix or hot mix

2/ The Costs: An example of a labour cost chart and equipment rental rates for calculating the unit cost of surface repairs are provided in Tables 4 and 5.

Crew Cost: In hot mix patching, a crew size of, say, 9 men will cost \$579.60/day (Table 4, box in heavy outline).

Equipment Cost: The cost of equipment rental is computed by summing the cost of equipment per day. The cost of a piece of equipment is dependent on rental rates and the number of hours it is used per day.

As an example, 1 crew carrier used for 6 hours a day at rental rates of \$3.10 per hour will cost \$18.60 per day.

Materials: The cost of materials is variable according to tender or local supply prices. The cost of these items is recorded on a form similar to that on Figure 3.

3/ The Total Cost of Maintenance per Day: The total cost of maintenance per day is the total of the crew cost, equipment cost and material cost per day.

4/ The Accomplishment per Day: This is the resultant outcome of processed materials per day.

5/ The Unit Cost is Dollars per Accomplishment Units:

$$\frac{\text{Total Cost}}{\text{Accomplishment}} = \text{Unit Cost}$$

6/ Annual Cost in dollars per year.

$$\frac{\text{Unit Cost}}{\text{Expected Life}} = \text{Annual Cost}$$

Similar cost calculations are also recorded for the alternative treatments of Cold Mix Patching and Spray Patching as shown in Figures 4 and 5.

Following the completion of these calculations for each alternative, a cost comparison may be made and the most cost-effective alternative is made evident. The conclusive evidence in this case is machine patching with Hot Mix. However, the urgency of maintenance, the availability of materials, equipment and funds and a variety of other factors should be considered before a maintenance treatment decision is made.

Table 3/ Example of Maintenance Performance Standard

This table shows an example of a maintenance performance standard, "M-1002-machine patching-placing and spreading". In addition to this table, the recommended method illustrated by photographs is also given as shown in Figure 2.

MAINTENANCE PERFORMANCE STANDARD

M-1002

MACHINE PATCHING
PLACING AND SPREADING

DESCRIPTION			
The machine placing and spreading of premixed asphaltic materials (hot or cold mix) to repair major surface defects such as depressions, bumps and other pavement defects. Includes preparation of patching area and compaction.			
ROAD TYPE HOT MIX MULTI-LANE	HOT MIX 2-3 LANE	MULCH 2-LANE	ALTERNATIVE METHOD FOR ALL ROAD TYPES
CREW SIZE 1-Grader Opr. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 2-Drivers (Traffic Cont.)	1-Grader Opr. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 3-Flagmen (Traffic Cont.)	1-Grader Opr. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 3-Flagmen (Traffic Cont.)	2-Screed Oprs. 1-Roller Opr. 2-Shovellers/Rakers 1 to 5-Drivers (Asphalt Supply) 1 to 2-Drivers or 1 to 3-Flagmen (Traffic Cont.)
EQUIPMENT 1-Crew Carrier 1-Grader 1-Roller 1 to 5-Dump Trucks 1 or 2-Sign Trucks or Sign Trailers	1-Crew Carrier 1-Grader 1-Roller 1 to 5-Dump Trucks	1-Crew Carrier 1-Grader 1-Roller 1 to 5-Dump Trucks	1-Crew Carrier 1-Tailgate Spreader 1-Roller 1 to 5 Dump Trucks 1 to 2 Sign Trucks/ Sign Trailers
MATERIALS Hot or Cold Mix	Hot or Cold Mix	Cold Mix	Hot Mix
ACCOMPLISHMENT Tonnes	Tonnes	Tonnes	Tonnes
MANHOURS PER ACCOMPLISHMENT 0.7 - 2	0.7 - 2	0.7 - 2	
ACCOMPLISHMENT PER DAY 105 - 35	105 - 35	105 - 35	

Table 4/ Example of Labour Cost Chart for Calculating Unit Costs of Surface Repairs (Crew Costs based on \$8.05/hour Standard Provincial Labour Rate 1979/80)

Men in Crew	1	2	3	4	5	6	7	8
1	8.05	16.10	24.15	32.20	40.25	48.30	56.35	64.40
2	16.10	32.20	48.30	64.40	80.50	96.60	112.70	128.80
3	24.15	48.30	72.45	96.60	120.75	144.90	169.05	193.20
4	32.20	64.40	96.60	128.80	161.00	193.20	225.40	257.60
5	40.25	80.50	120.75	161.00	201.25	241.50	281.75	322.00
6	48.30	96.60	144.20	193.20	241.50	289.80	338.10	386.40
7	56.35	112.70	169.05	225.40	281.75	338.10	304.45	450.80
8	64.40	128.80	193.20	257.60	322.00	386.40	450.80	515.20
9	72.45	144.90	217.35	289.80	362.25	434.70	507.15	579.60
10	80.50	161.00	241.50	322.00	402.50	483.00	563.50	644.00

Table 5/ Pre-Identified Equipment Listing And Rental Rates

Description Type	MTC Equipment Code	Current (1979) Rental Rates \$/h
1/2 ton pick-up	0003	\$3.00
3/4 ton pick-up	0006	3.10
3/4 ton 5 man cab	0006	3.10
1 1/2 ton stake/hoist	0023	3.90
1 1/2 ton 5 man cab	0023	4.05
3 ton dump	0031	7.10
4 ton dump	0041	8.40
5 ton dump	0051	
	0052	9.05
Grader 100 H.P.	0105	9.95
Portable Roller	0558	8.70
Portable Roller	0562	5.45
Portable Roller	0564	14.70
loader (1 1/4 cu. yd.)	0430	8.20
Asphalt Tailgate Spr.	0719	7.65
Maintenance Kettle	0420	7.35
Rubb/Asph. Kettle	0422	13.10
Concrete Saw (Router)	0630	9.80
Asphalt Distrib.	0892	17.45 add to truck
Pulvi-Mixer	0461	22.90
Pulvi-Mixer	0462	18.55
Aggregate Spreader	0721	28.35
Wobble Wheel Roller	0559	13.65
Steel Wheel Roller	0563	10.90
Steel Wheel Roller	0566	16.35
Steel Wheel Roller	0567	16.35
Broom Towed Type	0186	15.90
Air Compressor	0232	7.65
Air Compressor	0239	7.65
Jack hammer	0360	2.40
Sign Truck Unit	0655	3.80
Sign Trailer	0861	7.35

Figure 2/ Extract from Pavement Maintenance Guide

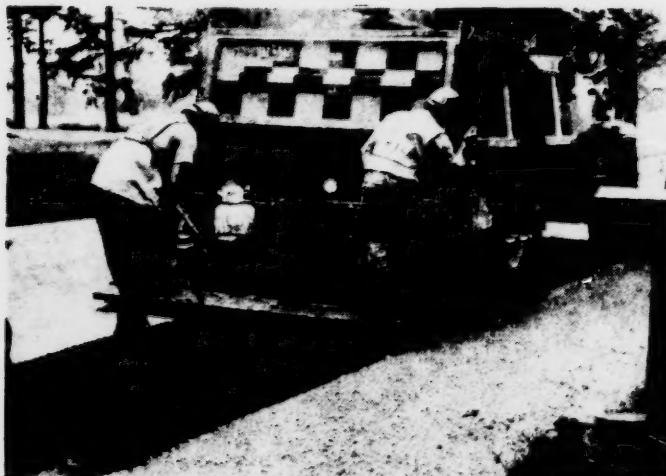
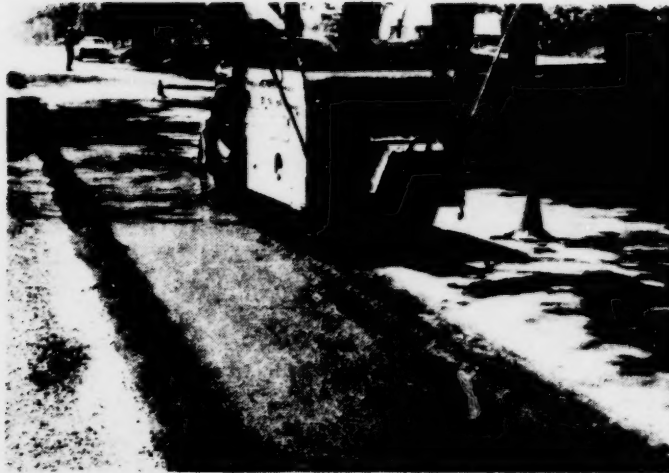
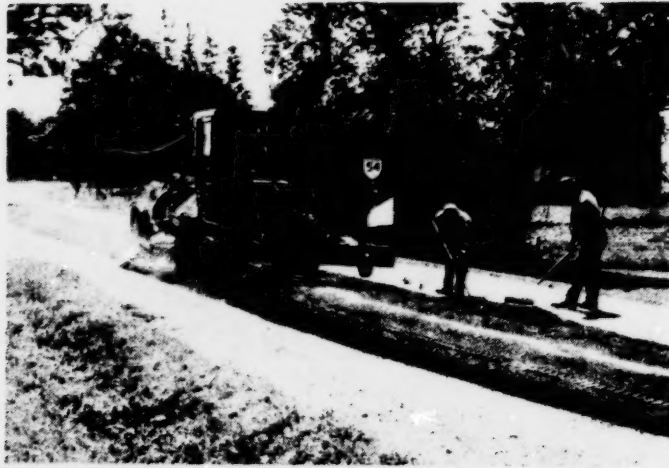
Recommended Method

1. Set up safety devices and signs in accordance with "Traffic Control Manual for Highway Work Operations."
2. Remove any loose or broken sections of existing pavement extending into the good pavement about 30 cm. Clean up the patch area, removing all loose material and water.
3. Compact the subgrade, if necessary.
4. Apply a tack coat at each end of the patch and along the centreline joint when one lane is to be patched.
5. Place and spread the mix with a grader or a tailgate spreader.
6. Smooth and feather out the edges of the patch.
7. Be sure that enough mix material has been placed to obtain the proper grade and cross-fall.
8. Compact the patch area, rolling progressively from the high side toward the low side, overlapping a few centimetres on each pass.

Note: Joints at the ends of the patch should be spray patched at a later date.

Procedures for Placing and Spreading Hot or Cold Mix Asphalt (Machine Patching)





MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO									
MAINTENANCE PRODUCTION UNIT COST AND ANNUAL COST									
OPERATION									
NUMBER	1002								
ACTIVITY	Hot Mix		Alligator Cracking; Moderate, Local						
	Patching								
CREW SIZE								REMARKS	
POSITION	CLASS	NO MEN	RATE	HOURS / DAY	COST	% OF TOTAL			
							Section of Highway to be prepared 30 km.		
							Std. Planning		
							Value Applied:		
							.8t/E2L km.		
							30 km x .8 t = 24 t Reqd.		
							24 t x \$33.03 =		
							\$792.72		
TOTAL		9	8.05	72	\$579.60				
EQUIPMENT COMPLEMENT									
TYPE	NO PCS	RATE	HOURS / DAY	COST	% OF TOTAL				
Crew carrier 3/4 T - 5M	1	\$3.10	6	\$ 18.60					
Dump truck 5 T	3	9.05	18	162.90					
Grader - 100 H.P.	1	9.95	6	59.70					
Roller	1	14.70	6	88.20					
TOTAL				\$329.40					
MATERIAL									
TYPE	QUANT. / DAY	UNIT	COST / UNIT	COST	% OF TOTAL				
	70	t	\$2004	\$1402.80					
TOTAL				\$1402.80					
GRAND TOTAL COST PER DAY				\$2311.80					
ACCOMPLISHMENT : PER DAY (APPROX.)					70 t				
PRODUCTION RATE : MAN-HOURS PER ACCOMPLISHMENT UNIT					1.029	ACCOMPLISHMENT MAN - HOURS			
UNIT COST : DOLLARS PER ACCOMPLISHMENT UNIT					\$ 33.03	TOTAL COST ACCOMPLISHMENT			
ANNUAL COST : DOLLARS PER YEAR					\$198.18	UNIT COST EXPECTED LIFE			

Figure 3/ Cost Calculation for Machine Patching – Hot Mix

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO									
MAINTENANCE PRODUCTION UNIT COST AND ANNUAL COST									
OPERATION			Alligator Cracking; Moderate, Local						
NUMBER	1004								
ACTIVITY	SPRAY								
	PATCHING								
CREW SIZE							REMARKS		
POSITION	CLASS	No MEN	RATE	HOURS / DAY	COST	% OF TOTAL	Section of Highway to be Repaired 30 km Std. Planning Value Applied; 71.69 ¢/E2L km 30 km x 71.69 ¢ = 2151 ¢ Reqd. 2151 x \$0.77 = \$1656.27		
TOTAL	7	7	\$8.05	56	\$450.80				
EQUIPMENT COMPLEMENT							Expected Life of Repair One Year		
TYPE	No PCS	RATE	HOURS / DAY	COST	% OF TOTAL				
Crew Carrier 3/4 T-M	1	\$3.10	6	\$ 18.60					
Dump Trucks - 5T	2	9.05	12	108.60					
Mtcs. Kettle	1	7.35	6	44.10					
Loader	1	8.20	1	8.20					
TOTAL					\$179.50				
MATERIAL							Expected Life of Repair One Year		
TYPE	QUANT. / DAY	UNIT	COST/ UNIT	COST	% OF TOTAL				
	1100	¢	\$.15	\$165.00					
	11.5	t	4.88	56.12					
TOTAL					\$221.12				
GRAND TOTAL COST PER DAY					\$851.42				
ACCOMPLISHMENT : PER DAY (APPROX)					1100 ¢				
PRODUCTION RATE : MAN-HOURS PER ACCOMPLISHMENT UNIT					0.051	ACCOMPLISHMENT MAN - HOURS			
UNIT COST : DOLLARS PER ACCOMPLISHMENT UNIT					\$ 0.77/¢	TOTAL COST ACCOMPLISHMENT			
ANNUAL COST : DOLLARS PER YEAR					\$1656.27	UNIT COST EXPECTED LIFE			

Figure 5/ Cost Calculations for Spray Patching

5/ VERIFICATION OF FORMAT

A draft format of the pavement distress manifestations and maintenance treatment alternatives was prepared as described in 4.1.1 and 4.2.1. In this draft it was suggested that certain maintenance treatments and alternatives are suitable for various pavement distress conditions (Table 2). The very significant item that was missing from the draft was the "Expected Effective Life" of a maintenance treatment, Column 4 of Table 2.

5.1/ Methodology

This draft together with a questionnaire were presented to a selected group of staff members within the Ministry and responses later solicited at individual interviews. The candidates interviewed were chosen for their present and past experiences in the area of pavement maintenance. In all, over 50 candidates were selected, each with maintenance-related experience of more than 20 years, i.e., an aggregate of more than 1,000 man-years of experience. Individual personal interviews to gain responses to the questionnaire followed the presentations. Information obtained was assembled and analyzed to establish the processes in the pavement maintenance guide, to verify the suitability of alternative treatments, and to provide the estimates of expected effective life for each treatment and condition.

5.2/ Questionnaire Results

Responses to the questionnaires indicated that, in general, the format presented is efficient, understandable, and simple for use as a management tool in the hands of the field maintenance staff. Overall, only minor changes, additions and deletions were required as a result.

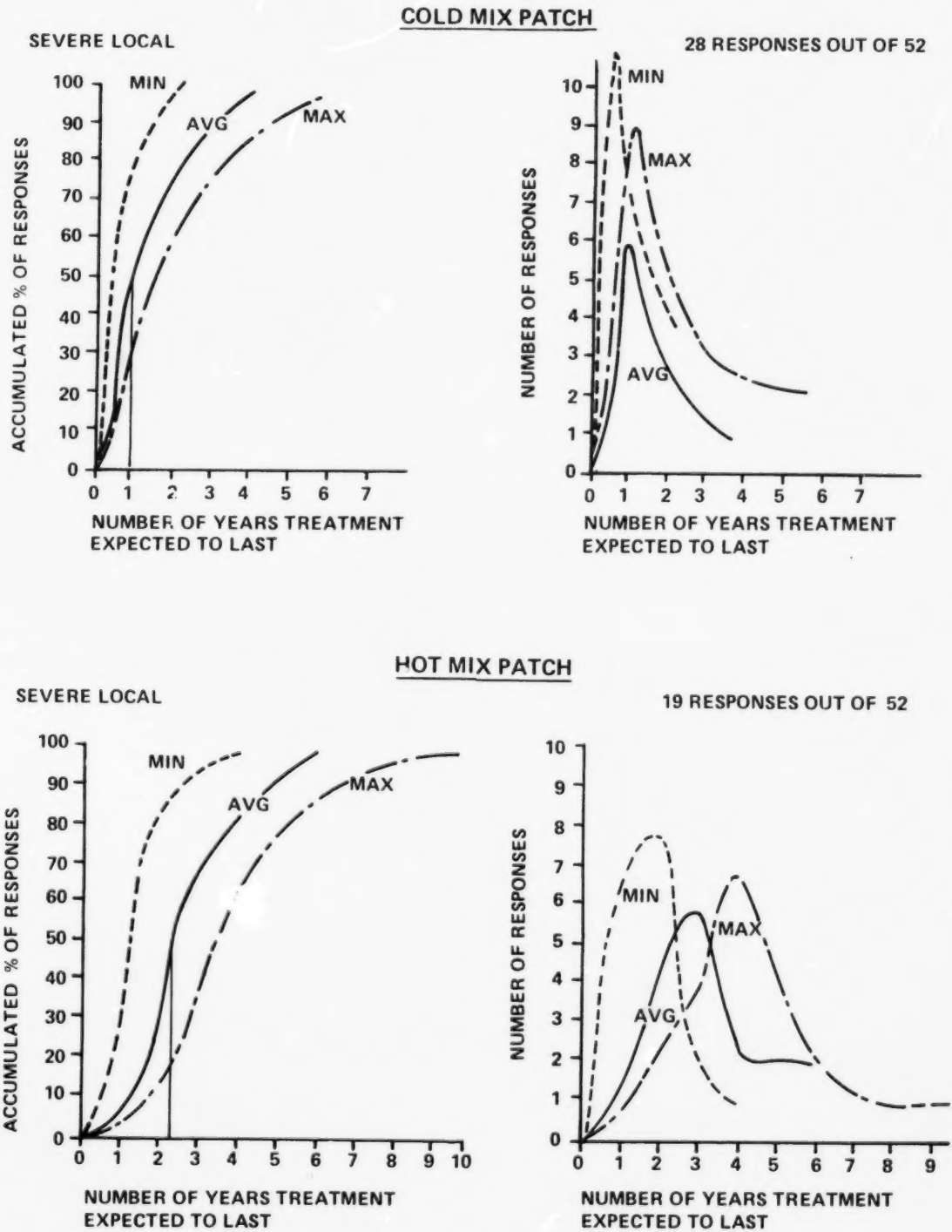
The missing, "Expected Effective Life" of the various maintenance treatments, was provided by the experienced personnel. The "Expected Life" given for each maintenance treatment under a

particular situation represents the median value of estimates provided by the interviewed subjects. An example of the analysis is given in Figure 6.

It should be clearly understood, however, that these "Expected Lives" based on past experiences are provided at this time only as a guide. An organized monitoring programme will be undertaken to verify many of these estimates. However, when it is realized that for rigid pavements there were 32 treatment situations for which lives were needed, and 102 for flexible pavements, making a total of 134 life estimates which were generated, this verification task appears formidable.

The results were assembled and a "Working Copy" of the pavement maintenance guide was established for pilot implementation.

Figure 6/ "Expected Effective Life" of Maintenance for Distortion of Severe/Local Condition



6/ WORKING COPY

The working copy consists essentially of three sections. The first describes to the patrolman how to use the guide to identify the extent and severity of any given type of distress; how to use the guide to identify suitable alternative maintenance treatments for the specific condition; how to calculate which of the alternatives is most cost-effective (provided it is an activity within his scope); and, finally, how to report the condition if the remedial measures are outside of his capability.

The second section consists of Distresses and Maintenance Alternatives for both Flexible Pavements and Rigid Pavements. The distresses for flexible pavements which are adequately illustrated with photographs are:

- 1/ Ravelling/Streaking
- 2/ Flushing
- 3/ Slippery Surface
- 4/ Pot Holes
- 5/ Rippling/Shoving
- 6/ Wheel Track Rutting
- 7/ Distortion - Sagging, Dishing, Depression, Settlement
 - Bump and Frost Related Bump
 - Excessive Crown and Transverse
 - Map
 - Progressive Edge Cracking/Edge Breaking
 - Alligator

The maintenance alternatives for these distresses are:

- 1/ Manual patching with cold mix or hot mix
- 2/ Machine patching with cold mix or hot mix
- 3/ Crack filling with or without routing
- 4/ Spray patching with liquid asphalt
- 5/ Mulch pavement with grader mixing or spreader mixing
- 6/ Surface treatment

- 7/ Cold planing
- 8/ Heater planing
- 9/ Burn and Seal
- 10/ Hot mix patching with recycled asphaltic materials

The distresses for rigid pavements which, again, are adequately illustrated by photographs are:

- 1/ Slippery Surface
- 2/ Scaling/Ravelling
- 3/ Pot Holes
- 4/ Stepping (Faulting)
- 5/ Sagging/Settlement
- 6/ Bump
- 7/ Joint Sealant Loss
- 8/ Joint Spalling
- 9/ Joint Failure
- 10/ Cracking

The maintenance alternatives for these distresses are:

- 1/ Manual patching with cold mix or hot mix
- 2/ Machine patching with cold mix or hot mix
- 3/ Cold planing
- 4/ Cut full-depth stress relief joints
- 5/ Joint and crack sealing
- 6/ Mud-jacking
- 7/ Concrete pavement repair with concrete
- 8/ Hot mix patching with recycled asphaltic materials

Distresses for Shoulder and Surface Drainage are also described, and illustrated, but no treatments are described:

- 1/ Pavement Edge Drop-off
- 2/ Excessive Shoulder Slope
- 3/ Erosion/Washout
- 4/ Encroaching Growth
- 5/ Pot Holes/Cracking (Stabilized or Paved Shoulders)
- 6/ Pavement/Shoulder Surface Drainage

The second section also includes guidelines which indicate to the patrolman (once the distress condition is identified) what the recommended alternative treatments are, whether they lie within his scope; the appropriate performance standard to use; and, finally, what life can be expected from application of the treatment.

The third and final section of the guidelines contain the performance standards. Each standard provides information on required crew size, equipment, materials, the unit of accomplishment, the man-hours per unit accomplishment, and the accomplishment per day. Further, the standard provides a step-by-step, fully illustrated description of the method used to carry out the treatment.

7/ PILOT IMPLEMENTATION

The "Working Copy" of the pavement maintenance guide, incorporating all the recommended changes, was printed for distribution in the pilot implementation study, the main objectives of the pilot study being to determine the practicability of the processes, the suitability of the treatments, the success of the cost-effectiveness approach, and to gauge the overall impression of the maintenance patrols to the greater recognition given to maintenance through these processes.

7.1/ The Approach

1/ Select a small number (14) of maintenance patrols in different geographical areas of the province (5 regions) to provide equal representation.

2/ Provide instruction through an audio/visual presentation to the patrolmen and patrol supervisory staff, of the proposed guide and its use, followed by a question-and-answer session.

3/ Examine the use of this guide as a management tool by the selected maintenance staffs.

4/ Through questionnaires and individually-conducted personal interviews, verify and establish the effectiveness of this guide.

7.2/ Pilot Implementation Results

The results, in general, indicated that the guide in its existing "working copy" format required only minor changes.

Highlights of the questionnaire results are:

- 1/ The guide as an entity is easy to use and understand.
- 2/ The guide provides uniformity in evaluation processes and management methodology.
- 3/ The guide offers a simple and functional system of identifying and describing the distress problems.
- 4/ The guide offers the appropriate maintenance alternatives for the distresses identified.
- 5/ The guide offers an easy-to-use methodology to compare and choose the most cost-effective maintenance alternative to the distress problem.
- 6/ At the patrol and patrol supervisory level, there is a developing awareness of their responsibility for choosing practical and cost-effective treatments, and a sure knowledge of their role in the task of pavement maintenance.

8/ APPLICATION OF FINDINGS AND IMPLEMENTATION

The findings from the pilot implementation project were assembled to effect the required changes in the "Working Copy". The result is the "Pavement Maintenance Guidelines: Distresses, Maintenance Alternatives and Performance Standards" (5).

Full implementation of this guide for general use by the field maintenance staff is being carried out by the Ministry's Maintenance Branch.

9/ FUTURE RESEARCH

Verification studies are necessary to provide the performance data on maintenance alternatives needed to verify life estimates used in the guide which were obtained through personal interviews of experienced maintenance staff.

Monitoring programs are also needed for work methodologies, materials and equipment to improve maintenance techniques and thus lengthen effective life of treatment.

New maintenance techniques and equipment, and new materials which are becoming available, should periodically be examined in future for extending the utility of the guidelines.

REFERENCES

- 1/ "Preventive Pavement Maintenance Concepts", W.A. Phang, W. Blum. Ministry of Transportation and Communications of Ontario, 1980.
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- 4/ "Maintenance Manual Quality Standard", Volume 1 and 3. Ministry of Transportation and Communications of Ontario.
- 5/ "Pavement Maintenance Guidelines: Distresses, Maintenance Alternatives and Performance Standards". G.J. Chong, F. Jewer, and K. Macey. Report No. SP-001, Ministry of Transportation and Communications of Ontario, 1980.

